

A.2.14 ASTROBIOLOGY SCIENCE AND TECHNOLOGY FOR EXPLORING PLANETS

1. Scope of Program

1.1 Introduction

A new era of planetary surface exploration has begun that is now investigating whether life exists or has existed beyond Earth that requires the development of biologically relevant, miniaturized instrumentation capable of extensive, autonomous operations on planetary surfaces (Mars first, then throughout the solar system). To this end, and in collaboration with the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA), this Astrobiology Science and Technology for Exploring Planets (ASTEP) program solicits proposals for investigations to explore the Earth's extreme environments in order to develop a sound technical and scientific basis to search for life on other planets. The ASTEP program is a science-driven exploration program that is expected to result in new science and operational/technological capabilities that enable the next generation of planetary exploration. A unique feature that is central to the ASTEP program is the use of field campaigns to further science and technology. Therefore, proposals that combine the following three concerted objectives will be given priority:

- 1) Science: ASTEP seeks science investigations designed to further biological research in the terrestrial environments analogous to those found on other planets, past or present. Such investigations should increase our understanding of the limits and constraints (or lack thereof) of life in extreme environments and, therefore, lead to a better understanding of how to seek, identify, and characterize life that may exist or have existed on other planets.
- 2) Technology: ASTEP seeks the development of technologies that enable remote searches for, and identification of, life in extreme environments (including planetary surfaces) including, but not limited to, *in situ* laboratories, sample acquisition and handling techniques, remote sample manipulation, mobile science systems (including planetary rovers), techniques for autonomous operations, and self-contained deployment systems.
- 3) Field Campaigns: ASTEP supports systems-level field campaigns designed to demonstrate and validate the science and technology in extreme environments on Earth. It is expected that such field campaigns will be conducted with complete systems and in a manner that approximates their operations in an actual planetary mission in order to understand the performance, capabilities, and efficiencies associated with the tested systems, as well as gain operational experience.

In summary, ASTEP is expected to lower the risks of planetary exploration through technology development and systems-level field tests in Earth's extreme environments that will also obtain scientific data and operational experience.

The high visibility missions to the Earth's extreme environments that are expected to be supported through this program element should also provide significant opportunities for student involvement in exploration, thereby inspiring a technologically competent next generation of scientists, engineers, and citizens. Therefore, proposals to ASTEP that provide for student involvement (both graduate as well as undergraduate) are encouraged. In addition, proposals are also sought that incorporate Education/Public Outreach (E/PO) activities through telepresence capabilities and involvement of professional educators and students nation-wide in the fun and challenges of science and technology. Further guidance on the E/PO program sponsored by the Office of Space Science may be found in Section 4 of the *Summary of Solicitation* of this NRA. Conversely, proposers who prefer not to propose a significant E/PO effort should state in their proposals whether they are willing to host an outside E/PO activity arranged by NASA.

In recognizing the needed development of miniaturized instrument systems, with this solicitation NASA is also initiating a "lab-in-a-teacup" development project. The goal is to apply micro/nanotechnology to planetary instrumentation and highly integrated miniature instruments suites with the capability to address astrobiology interests in planetary exploration. This is a specific call for instrumentation, without necessarily being associated with a field campaign.

1.2 Program Guidelines and Constraints

Astrobiology is the study of life in the Universe whose goals and objectives are detailed in the Astrobiology Roadmap (see <http://astrobiology.arc.nasa.gov/>). The Office of Space Science has planned and is planning missions to Mars and to other planetary bodies of Astrobiology interest (see <http://spacescience.nasa.gov/>).

It is intended that the products of the ASTEP Program will be initially utilized by the space flight projects planned for the NASA Mars Exploration Program (MEP) (<http://mars.jpl.nasa.gov/>) and the NASA Solar System Exploration Program (<http://sse.jpl.nasa.gov/>).

Technology development and field test campaign proposals in all areas relevant to astrobiology and planetary exploration goals and objectives will be considered for the ASTEP program. However, the program recognizes a particular need for proposals for technology maturation, science data collection, and operations analysis in the following areas:

- Surface sample acquisition, handling, and distribution systems;
- Instrument suites for *in situ* identification and analysis of biomarkers;
- Long-term characterization of life-supporting environments;
- Integration of science instrument suites with mobile platforms (rovers);
- Autonomous instrument deployment and placement;
- Autonomous recognition of unexpected science phenomena;
- Self-contained mobile science systems;

- Mobile science platforms; and
- Subsurface sample acquisition systems.

Several science and technology development programs have produced component technologies, capabilities, and resources that may be of utility in constructing complete systems for field test campaigns or further technology development. Utilization and leveraging of these component technologies and/or subsystems is permitted and encouraged. References and further information on these representative technologies can be found on the World Wide Web at <http://ranier.hq.nasa.gov/ASTEP/astep.html>.

1.3 Campaigns for Field Tests

Field campaigns for the testing of technologies relevant to this ASTEP program may be proposed and may cover a wide range of environments that are analogous to different past or present planetary environments. Examples of field test campaigns are given below to demonstrate the breadth, applicability, and excitement of this approach (Note: these examples are only representative of possible campaigns and do not represent either explicitly or exclusively all possibilities). Finally, note that while proposals for field test campaigns are encouraged in response to this solicitation, it is incumbent on the proposer to demonstrate that access to the site proposed for the operation of experiment apparatus is in fact tenable both physically and, for those locales not under the control of the U.S., politically, and that appropriate budget resources are allocated for the operations.

Remote Explorer

Ground-based systems can provide platforms for detailed local investigations of regions identified as likely candidate locations for the detection of life signs. For example, such a project might seek to validate remote long duration and autonomous science operations and technologies by combining an existing mobile robotic platform with a representative suite of astrobiology instruments, deploying the system in a remote location (for example, the Earth's polar regions), and operating the system from the continental U.S. through a telecommunications link consistent with those used for communications with NASA's planetary missions.

Volcanic Firewalker

Ancient and active volcanoes exist throughout the solar system and may have provided key ingredients for life-supporting environments (energy, chemistry, and possibly liquid water) and, therefore, are high priority targets for searches for evidence of life. Thus, the deployment of a robotic exploration system to search and analyze the interior of volcanic craters, including fumaroles, to identify potential habitats for life could validate science operations and technologies for exploring similar features on other planets.

Ice Penetrator

Sub-ice oceans on Europa may harbor life-supporting environments. Methods and technologies for accessing and exploring environments beneath deep ice cover are not well understood and could be tested in the Earth's own polar regions.. Such efforts would focus on the technical challenges of ice penetration, of planetary protection through the use of non-contaminating sampling techniques, of the potential for environmental degradation, of communication and exploration systems, and of biomarker identification in extremely low-energy environments.

Hydrothermal Vent Monitor

Using the terrestrial subsea environment as an analog for Europa or other early planetary environments, a campaign to conduct long term examinations of deep sea volcanic vents, as well as more violent eruptions that could even bring life forms from far beneath the sea floor to the surface, would be relevant to the ASTEP program. Deep-sea exploration platforms ("aqua-bots") exist but require considerable surface infrastructure that is not tenable for a space flight mission. However, it might be possible to modify such a system for stand-alone operation in support of biology science packages. Such a campaign might conduct operations with only minimal intervention for many months or even years, therefore, requiring the development of systems having a significant degree of autonomy.

2. Programmatic Information

2.1 Guidance for Field Test Campaigns

Interagency collaboration in this solicitation recognizes the broad interest in the value of exploring extreme environments while simultaneously developing robotic capabilities that may be of value to NASA's planetary exploration program. Therefore, this ASTEP program announcement allows a single proposal for both research support, as well as for access to extreme polar and/or under-sea environments in which to test the hardware that is proposed for development.

The NSF funds and manages the U.S. Antarctic Program (USAP), which carries forward the Nation's goal of supporting the Antarctic Treaty, fostering cooperative research with other nations and protecting the Antarctic environment, among other activities. Research is supported in Antarctica that can only be done, or can best be done, there. For research that requires access to Antarctica, information concerning logistical support may be obtained from:

Mr. Brian Stone
Polar Research Support Section
Office of Polar Programs
The National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230
Telephone: (703) 292-7458
E-mail: bstone@nsf.gov

Additional information is available in publication NSF 02-086, available at <http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf02086>. Please note that an Operational Requirements Worksheet (ORW) as described in NSF 02-086 must be submitted electronically to the U.S. Antarctic Program for proposals requiring field support in Antarctica. Note that planning for Antarctic fieldwork must begin at least 18 months in advance of field deployment and must include an analysis of the environmental impact of the proposed project. In addition, programs proposed for work in Antarctica must be consistent with international planning efforts undertaken in cooperation with Antarctic Treaty nations, where applicable.

For projects proposing work in the Arctic, logistics support information is available from the NSF Arctic Research Support and Logistics program by contacting:

Mr. Simon Stephenson
Arctic Research Support and Logistics
Office of Polar Programs
The National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230
Telephone: (703) 292-7435
E-mail: sstephen@nsf.gov

Additional information for fieldwork activities is available at <http://www.vecopolar.com/>.

Proposers requiring the use of a University-National Oceanographic Laboratory System (UNOLS) ship or submersible, or a U.S. Coast Guard (USCG) icebreaker in the Arctic, must submit a ship request form to NSF's Division of Ocean Sciences as well as the UNOLS office and the operator of any requested ship or ships. For further information, contact:

Dr. Michael Reeve
Head, Integrated Programs Section
Division of Ocean Sciences
The National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230
Telephone: (703) 292-8580
E-mail: mreeve@nsf.gov

Ship request forms are available electronically on the UNOLS site at <http://www.unols.org/scheduling.html>. Printed copies of the form may be obtained from the UNOLS office (telephone: (401) 874-6825).

Finally, the possibility exists for scientists to carry out ASTEP investigations from an icebreaker in the Arctic Ocean in collaboration with the NOAA Arctic Exploration Program. For further information contact:

Dr. Kathleen Crane
Program Manager - Arctic Research Office
National Oceanic and Atmospheric Administration
1315 East-West Highway,
Silver Spring, MD 20910
Telephone: (301) 713-2518 Ext. 147
E-mail: kathy.crane@noaa.gov

2.2 Program Funding, Schedule, and Proposal Preparation

It is anticipated that \$6.0M will be available to support ASTEP new investigations selected through this program, with funding to begin in FY 2004, which is considered sufficient to support up to three field test campaign investigations and several technology/science development tasks, where it is understood that the field campaigns will necessarily be much more expensive than proposals for laboratory developments. Funds are also specifically set aside for initiating at least two “lab-in-a-teacup” research activities. Furthermore, telepresence activities during some field campaigns are expected to be supported. Due to the relative near-term nature of the planned Mars surface missions, priority will be given to proposed activities with documented relevance to the Mars Exploration Program (see Section 1.2 above in this program element), as well as the potential to affect missions planned for 2009 and later. Proposals may specify periods of performance of up to three years.

In order to make the best possible use of the funds available, proposers are encouraged to seek cost sharing where appropriate and to propose collective use where that is reasonable, e.g., instruments that could be made available for use by other qualified members of the astrobiology and planetary science community.

Finally, note that to enable the NASA Office of Space Science to properly evaluate the relevance of proposals submitted to its programs, as well as track its progress towards achieving its goals as mandated by the Government Performance Review Act (GPRA), all research supported by NASA's programs must now demonstrate its relationship to NASA Goals and Research Focus Area's (RFA's) as stated in the latest version of its Strategic Plan (follow links from the Web site <http://spacescience.nasa.gov/>); see also the discussion in Section 1 of the *Summary of Solicitation* of this NRA. Therefore, all proposers to this program element are asked to state their perception of this relevance in terms of the Goals, Science Objectives, and RFA's given in Table 3 found in the *Summary of Solicitation*. The appropriate place for this statement of relevancy is in the introduction to the proposal's "Scientific/Technical/Management" section (see Section 2.3.5 in the *Guidebook for Proposers*). The index numbers in this table may be used to identify a specific RFA, for example, "Goal I, Sun-Earth Connection Theme, RFA 1(c)" or "Goal II, Astronomical Search for Origins, RFA 3(b)."

In recognition of the inherent complexity of proposing a science-driven exploration activity, **20 pages are permitted for the Scientific/Technical/Management section of the proposal** instead of the 15 pages specified in Section 2.2 of the *NASA Guidebook for Proposers*).

The evaluation criteria contained in Appendix C, Section C.2, of the *NASA Guidebook for Proposers* (see further below) shall be used to evaluate submitted proposals, where it is understood that the scientific and technical merit of any proposal for a terrestrial field test campaign will also include the following factors, of equal priority:

- A clear understanding of the campaign environment and the science to be addressed;
- Feasibility and appropriateness of the proposed instruments and the operational approach;
- The fidelity of the campaign operations and location to the analogous planetary mission; and
- The relevance and added value of the included technologies to Astrobiology science and planetary exploration.

The recommendation for funding will be based on the peer evaluation of the scientific and technical merits of each proposal, as well as the broader impacts of the activity, the relevance to NASA's Astrobiology and planetary exploration programs, and the ability to support the requested budget and logistics. NASA will manage the review process and the administration of the program with assistance and participation of NSF and NOAA as appropriate.

Progress reports for funding the second or subsequent years of research, for previously approved multiple year awards, will be considered separately and should be sent directly to the Astrobiology Program Officer 60 days before their funding anniversary date . Also,

the participation of all selected investigators in the annual ASTEP Program review will be required.

IMPORTANT INFORMATION

- As discussed in the *Summary of Solicitation* of this NRA, the Office of Space Science (OSS) now uses a unified set of instructions for the preparation and submission of proposals given in the document entitled *NASA Guidebook for Proposers Responding to NASA Research Announcement - 2003* (or *NASA Guidebook for Proposers* for short) that may be accessed by opening <http://research.hq.nasa.gov/> and linking through "Helpful References," or by direct access at <http://www.hq.nasa.gov/office/procurement/nraguidebook/> (note that the updated 2003-edition of the *Guidebook* is used for this solicitation).
- Section 6 of this NRA's *Summary of Solicitation* contains the Web address relevant to the electronic submission of a Notice of Intent (NOI) to propose and a proposal's *Cover Page/Proposal Summary/Budget Summary*, as well as the mailing address for the submission of the hard copies of a proposal.

Questions concerning this ASTEP program may be directed to either of the following Program Officers:

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